Regional Species Modeling and Data Integration

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NOAA LOYOLA UNIVERSITY CHICAGO Marine Geospatial Ecology Lab Duke University NCCOS

  

Objectives:

- Cetacean density modeling
- Regional marine life data synthesis

…Data needs and collaborative possibilities

SCIENTIFIC REPORTS

OPEN

Habitat-based cetacean density models for the U.S. Atlantic and Gulf of Mexico

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Cetaceans are protected worldwide but vulnerable to incidental harm from an expanding array of human activities at sea. Managing potential hazards to these highly-mobile populations increasingly requires a detailed understanding of their seasonal distributions and habitats. Pursuant to the urgent need for this knowledge for the U.S. Atlantic and Gulf of Mexico, we integrated 23 years of aerial and shipboard cetacean surveys, linked them to environmental covariates obtained from remote sensing and ocean models, and built habitat-based density models for 26 species and 3 multi-species guilds using distance sampling methodology. In the Atlantic, for 11 well-known species, model predictions resembled seasonal movement patterns previously suggested in the literature. For these we produced monthly mean density maps. For lesser-known taxa, and in the Gulf of Mexico, where seasonal movements were less well described, we produced year-round mean density maps. The results revealed high regional differences in small delphinoid densities, confirmed the importance of the continental slope to large delphinoids and of canyons and seamounts to beaked and sperm whales, and quantified seasonal shifts in the densities of migratory baleen whales. The density maps, freely available online, are the first for these regions to be published in the peer-reviewed literature.

The International Whaling Commission placed a moratorium on commercial whaling in 1986, curtailing the biggest direct anthropogenic threat to many cetacean populations. But other threats have persisted, such as bycatch in fisheries[1], ship strikes[2], oil spills[3,4], and other pollutants[5]. New threats have been recognized, including naval active sonar[6–8], other anthropogenic sources of noise[9,10], and climate change[11]. In the United States, national laws protect cetaceans. The Marine Mammal Protection Act (MMPA) prohibits intentional or incidental killing, injuring, or harassment of cetaceans and specifies the circumstances and rules under which permits may be issued for such activities. The Endangered Species Act (ESA) prohibits harm to species threatened with extinction, including 16 cetacean species, and requires conservation of their habitat. The National Environmental Policy Act (NEPA) specifies the process by which U.S. national government agencies must evaluate the potential environmental effects of their actions, consider alternatives, and conduct public reviews. Agency actions that involve decisions to issue permits under the MMPA or ESA are usually subject to this process.

To evaluate the potential effects of proposed activities on cetacean populations, interested parties require a detailed understanding of the spatiotemporal distributions of these populations. Recent developments have created an urgent need for this information in U.S. waters of the Atlantic and Gulf of Mexico, when the U.S. Bureau of Ocean Energy Management (BOEM) proposed to open a large portion of the Atlantic continental shelf to oil and natural gas development and to expand oil and gas leasing in the Gulf of Mexico. Concurrently, the U.S. Navy began development of a new Environmental Impact Statement assessing the effects of training activities proposed for a large portion of the western North Atlantic, while the National Marine Fisheries Service (NMFS) proposed

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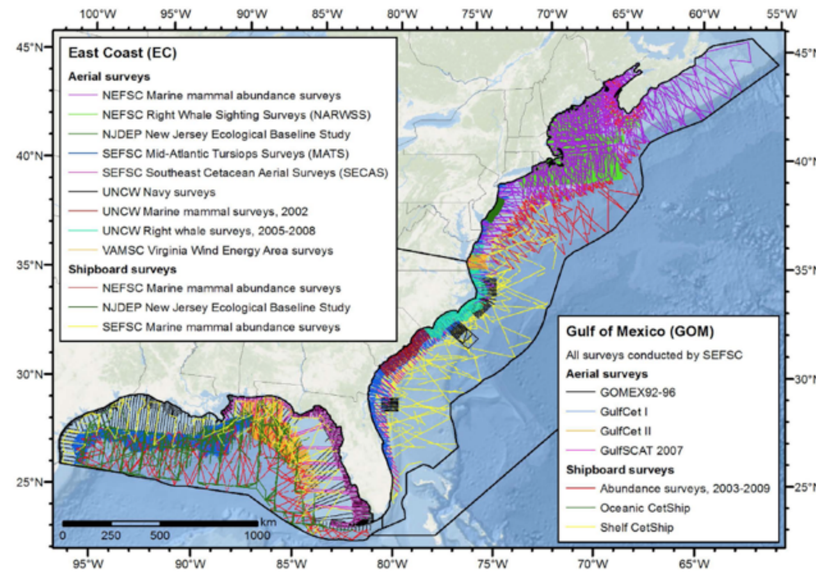
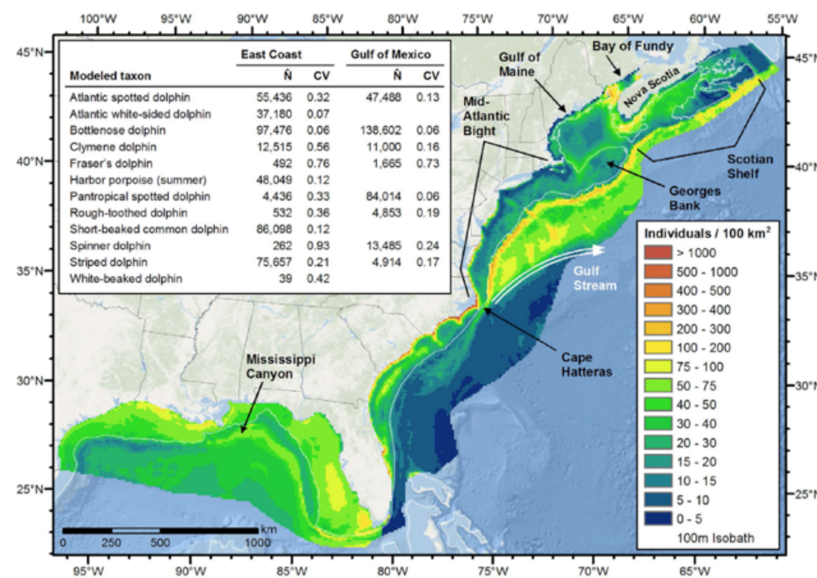
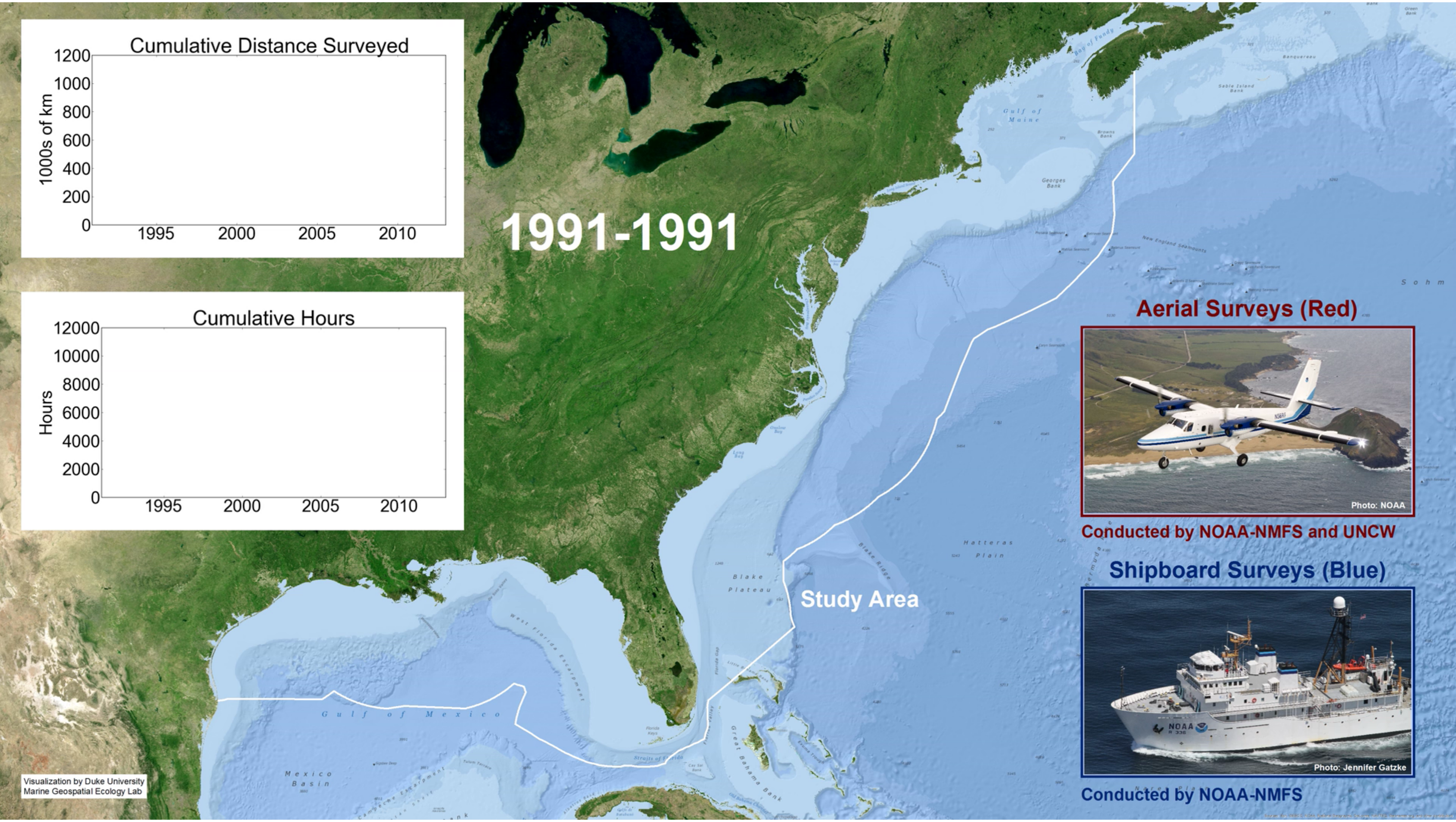
http://www.nature.com/articles/srep22615





Marine mammal aggregation data overview

Marine Geospatial Ecology Lab
Duke University



Cetacean habitat modeling process

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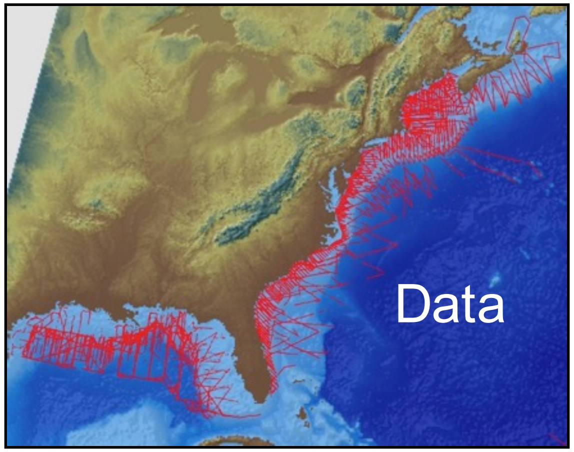
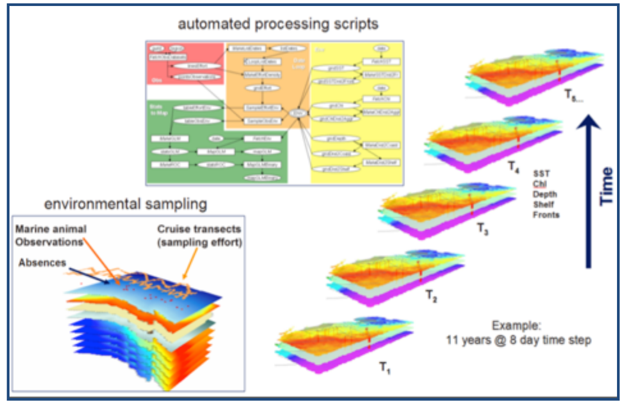
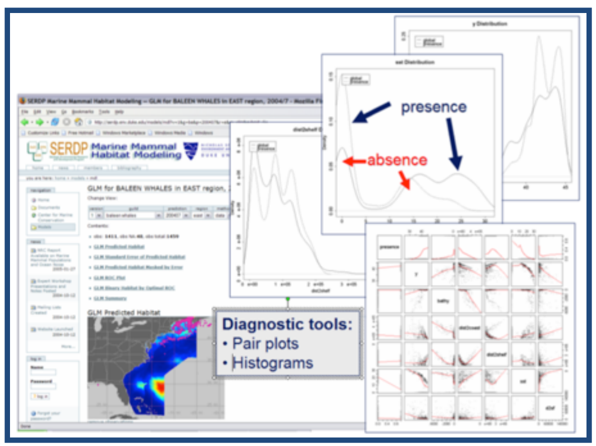
1: observation data aggregation



2: fusion with oceanographic data



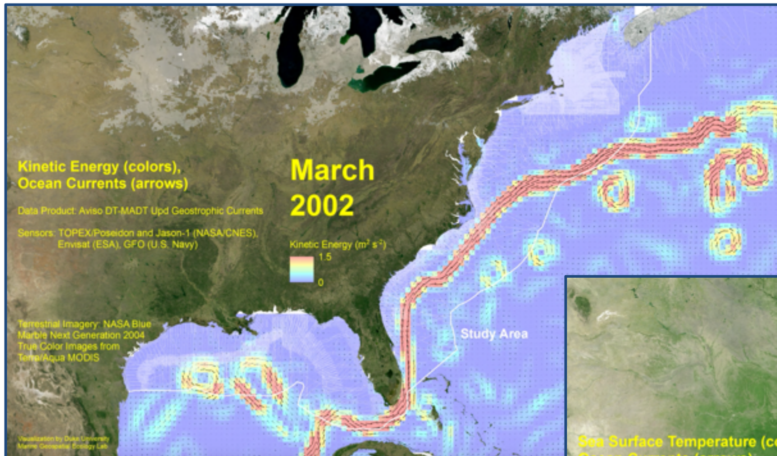


3: statistical modeling

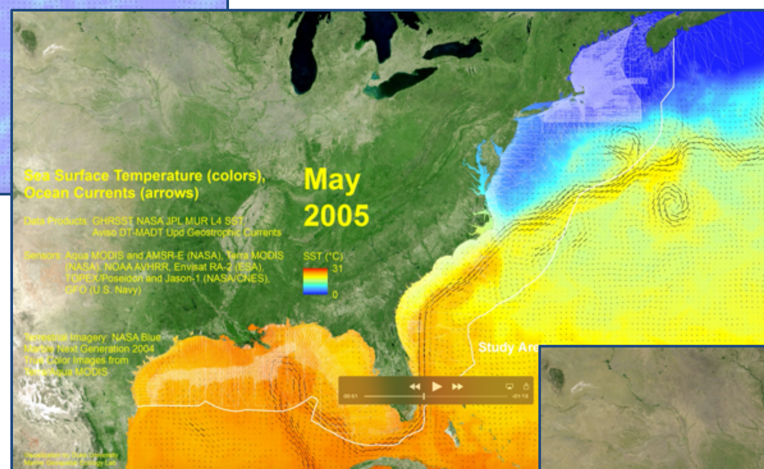
4: model product development

Dynamic oceanographic predictor variables

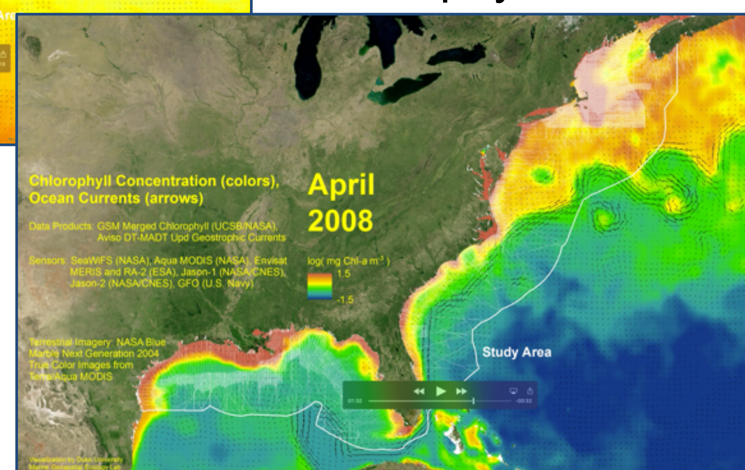
currents, eddys & kinetic energy



sea surface temperature



chlorophyll a



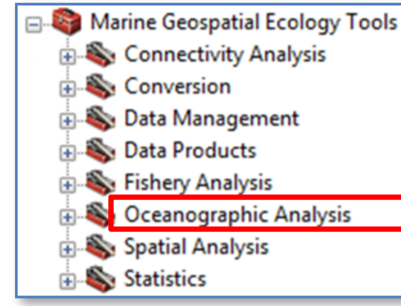
Physical oceanographic predictors

Predictor	Description
SST	Taken from GHRSST CMC 2.0 L4 0.2° daily SST, interpolated up to 10 km resolution
DistToFront	Distance to closest SST front detected in CMC SST using Canny edge detection operator. Tested several alternative formulations.
DistToEddy, DistToAEddy, DistToCEddy	Distance to ring of closest geostrophic eddy having any/anticyclonic/cyclonic polarity, from Chelton et al. (2011) database. Tested eddies at least 9 weeks old, at least 4 weeks old, and without a minimum age.
TKE, EKE	Total kinetic energy and eddy kinetic energy derived from AVISO 1/4° DUACS 2014 geostrophic currents, interpolated up to 10km resolution
WindSpeed	30 day running mean of NCDC 1/4° Blended Sea Winds

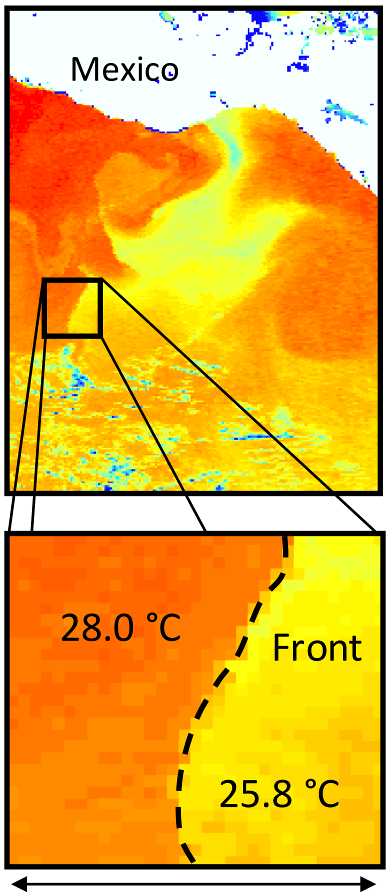
Identify fronts in SST images

MGET: Marine Geospatial Ecology Tools

Roberts *et al.* 2010

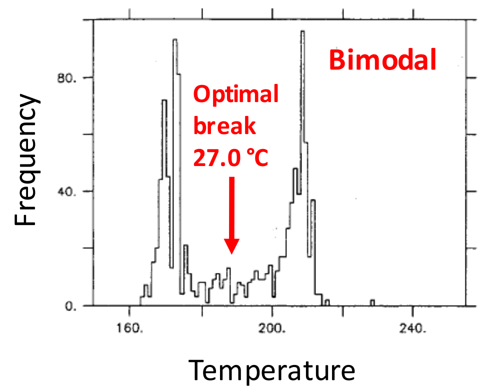


AVHRR Daytime SST
03-Jan-2005

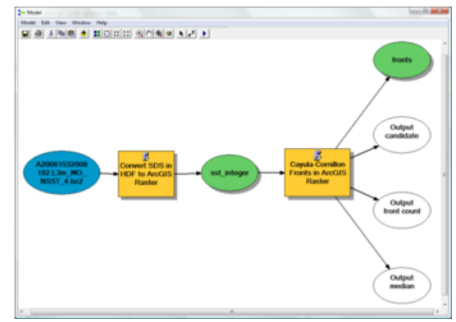


Cayula and Cornillion (1992) edge detection algorithm

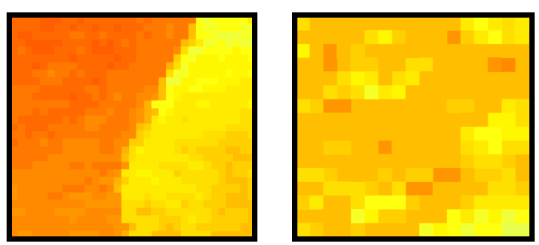
Step 1: Histogram analysis



ArcGIS model



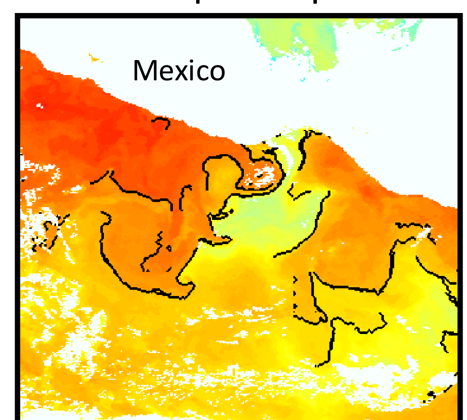
Step 2: Spatial cohesion test



Strong cohesion → front present

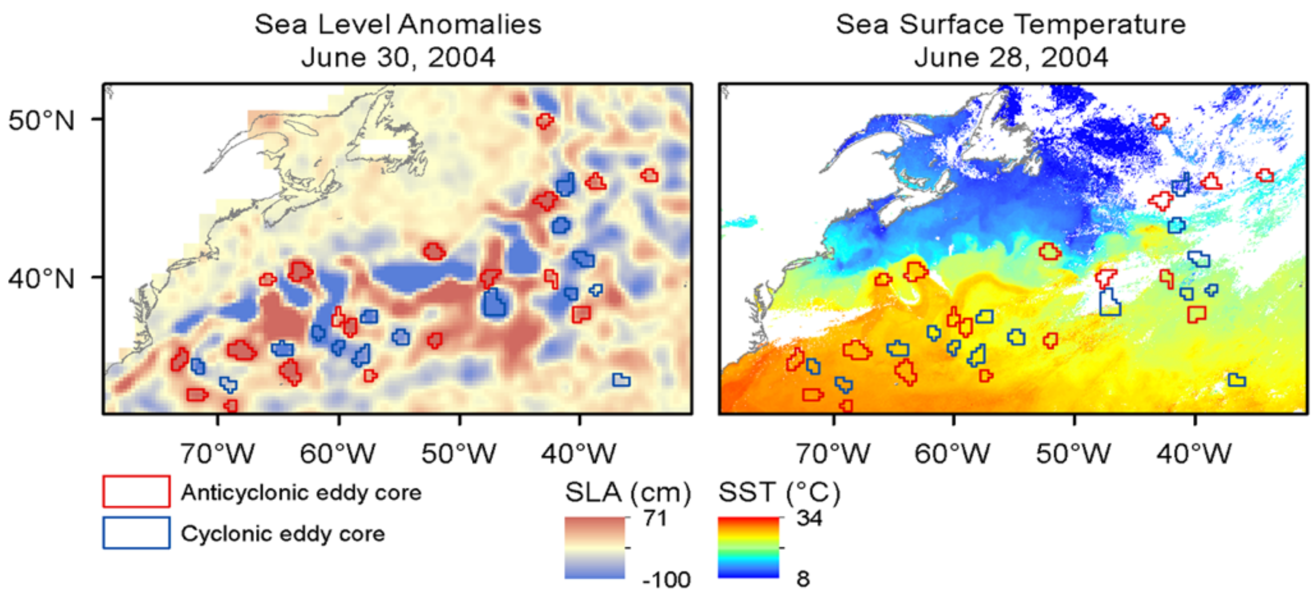
Weak cohesion → no front

Example output

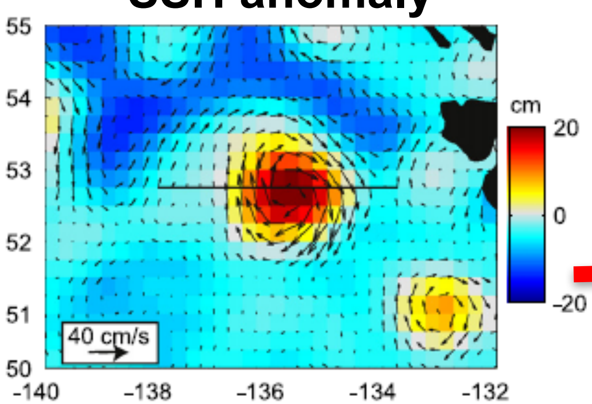


Dynamic oceanographic covariates

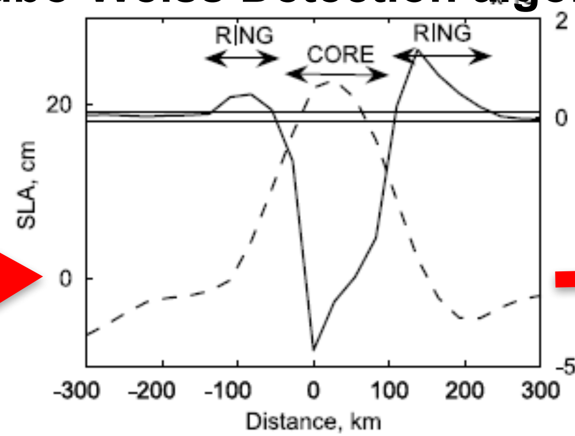
Detecting sea height anomalies & eddys



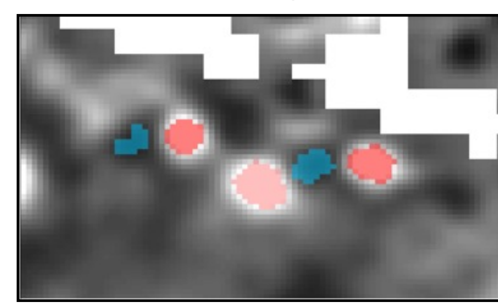
SSH anomaly



Okubo-Weiss Detection algorithm



Derived eddy features

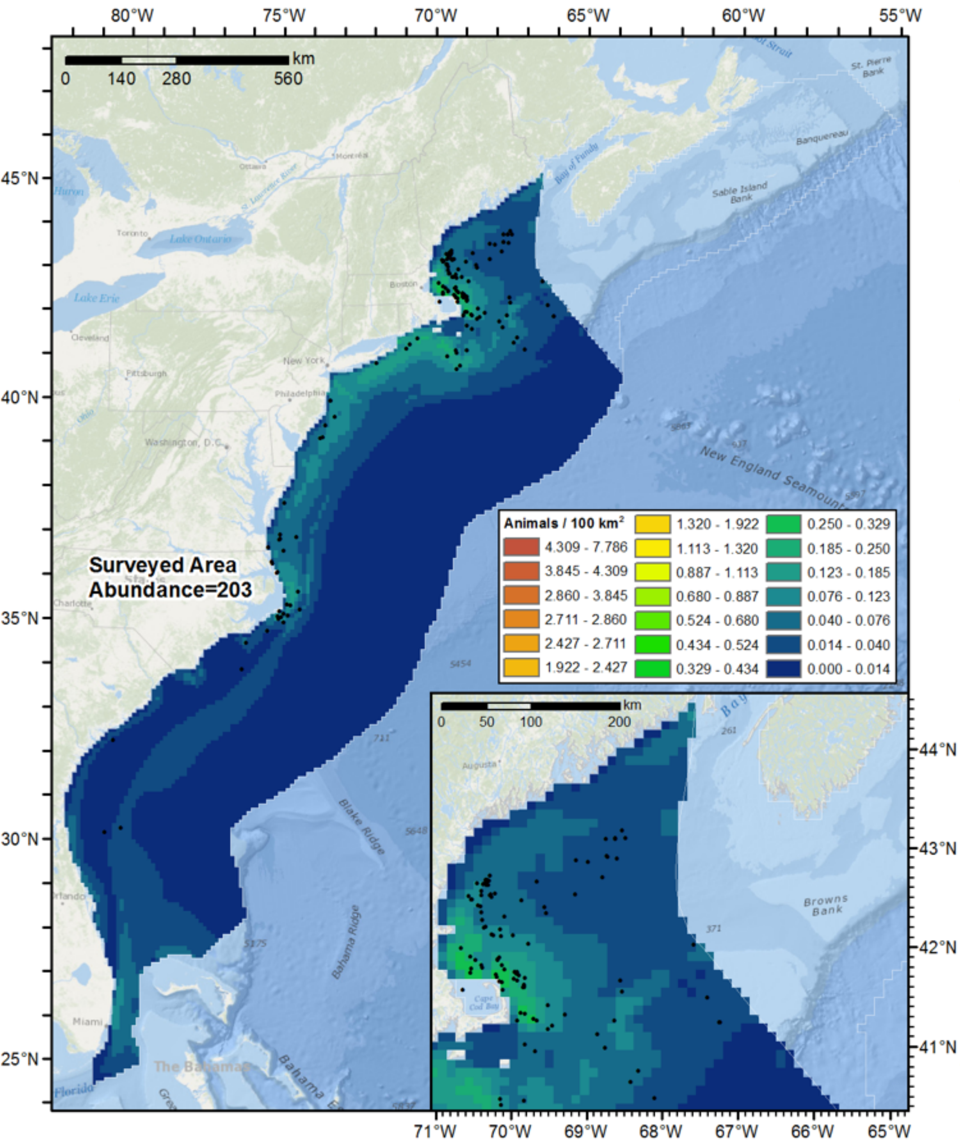


Aviso DT-MSLA 27-Jan-1993

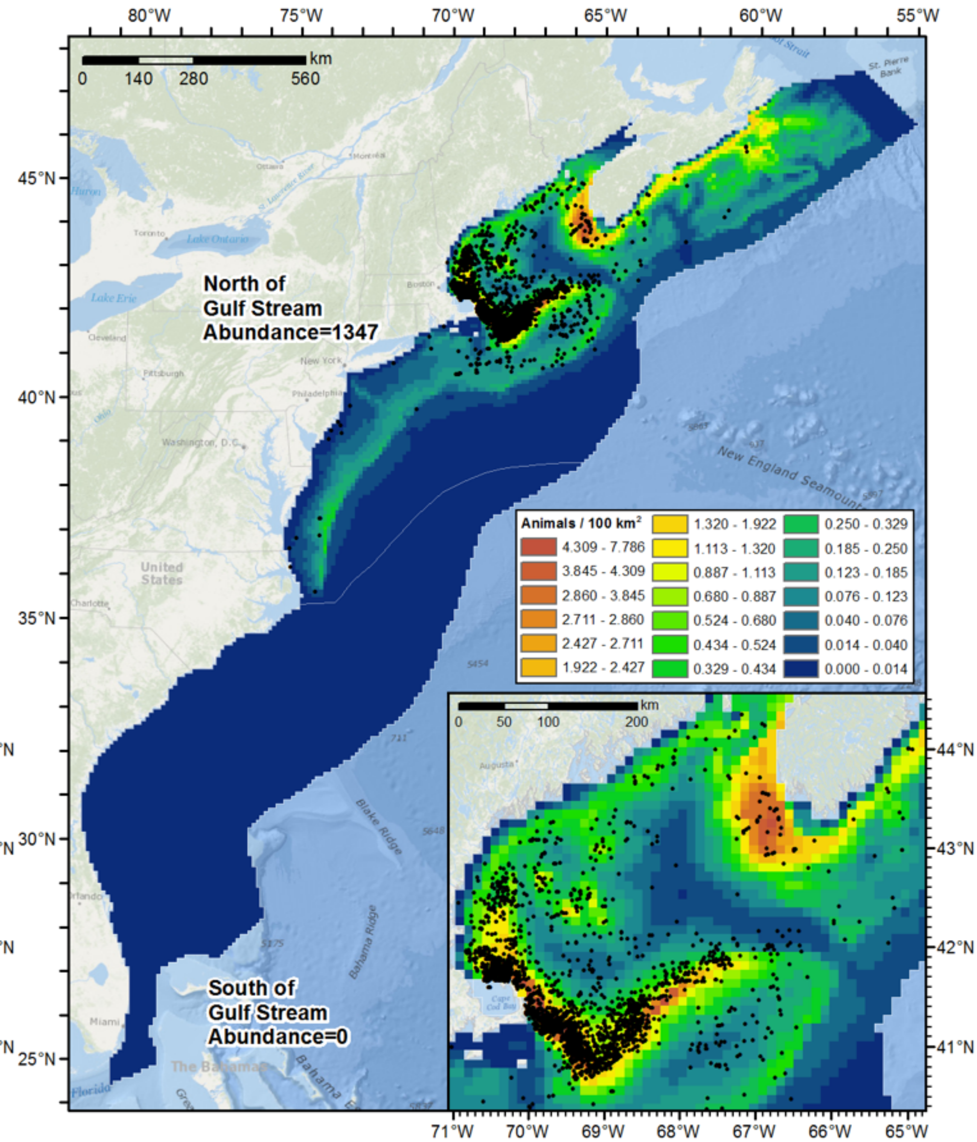
Red: Anticyclonic Blue: Cyclonic

Humpback whales

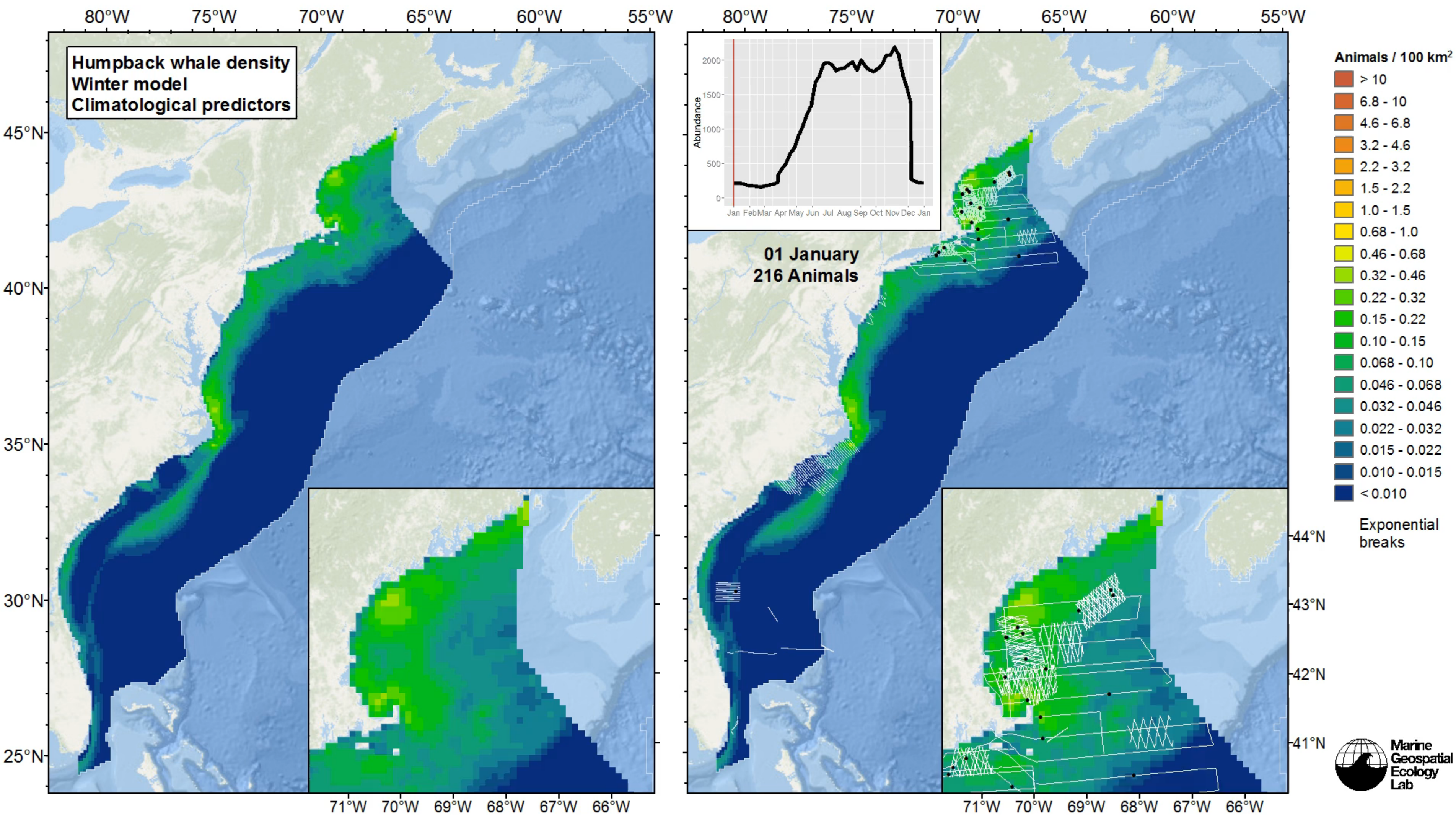
Winter



Summer



Humpback whale, predicted daily to illustrate dynamics

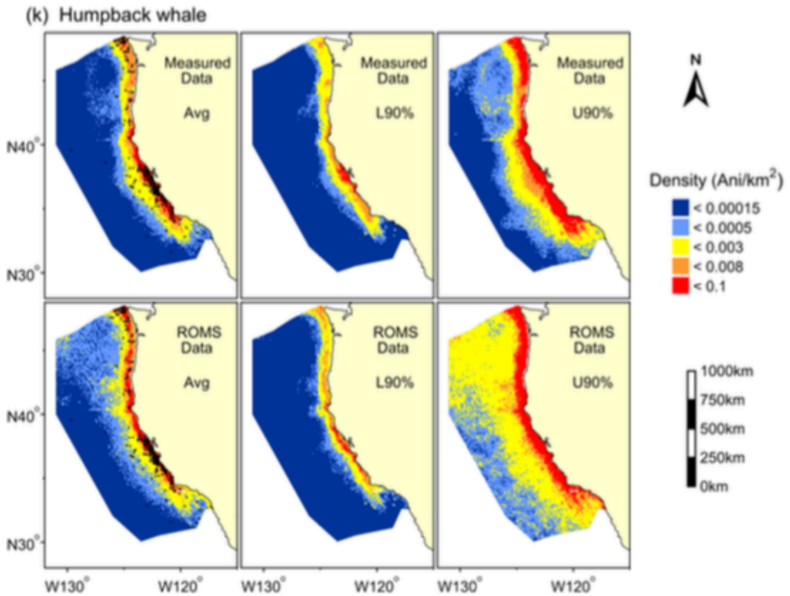


Formal result was 12 monthly summary maps

Data Needs and Collaborative Opportunities

Ocean circulation models and observations to improve cetacean model predictors

- Improve resolution
- Hindcasting, Forecasting

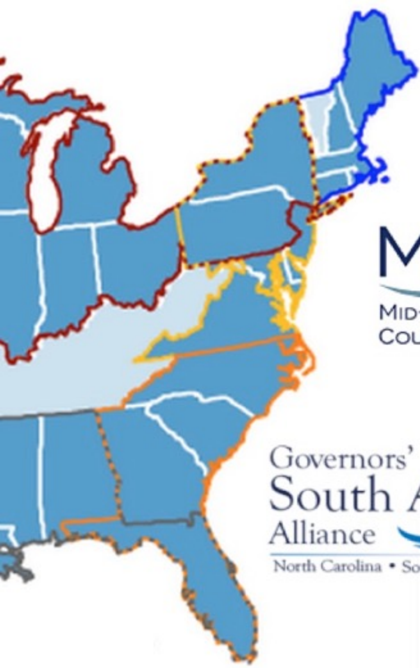


Becker *et al.* 2016



Objectives:

- Cetacean density modeling
- Regional marine life data integration



NROC
Northeast Regional Ocean Council

NE Regional Planning Body

MARCO
Mid-Atlantic Regional Council on the Ocean

Mid-Atlantic Regional Planning Body

Governors' South Atlantic Alliance
North Carolina • South Carolina • Georgia • Florida

No Regional Planning Body

MDAT

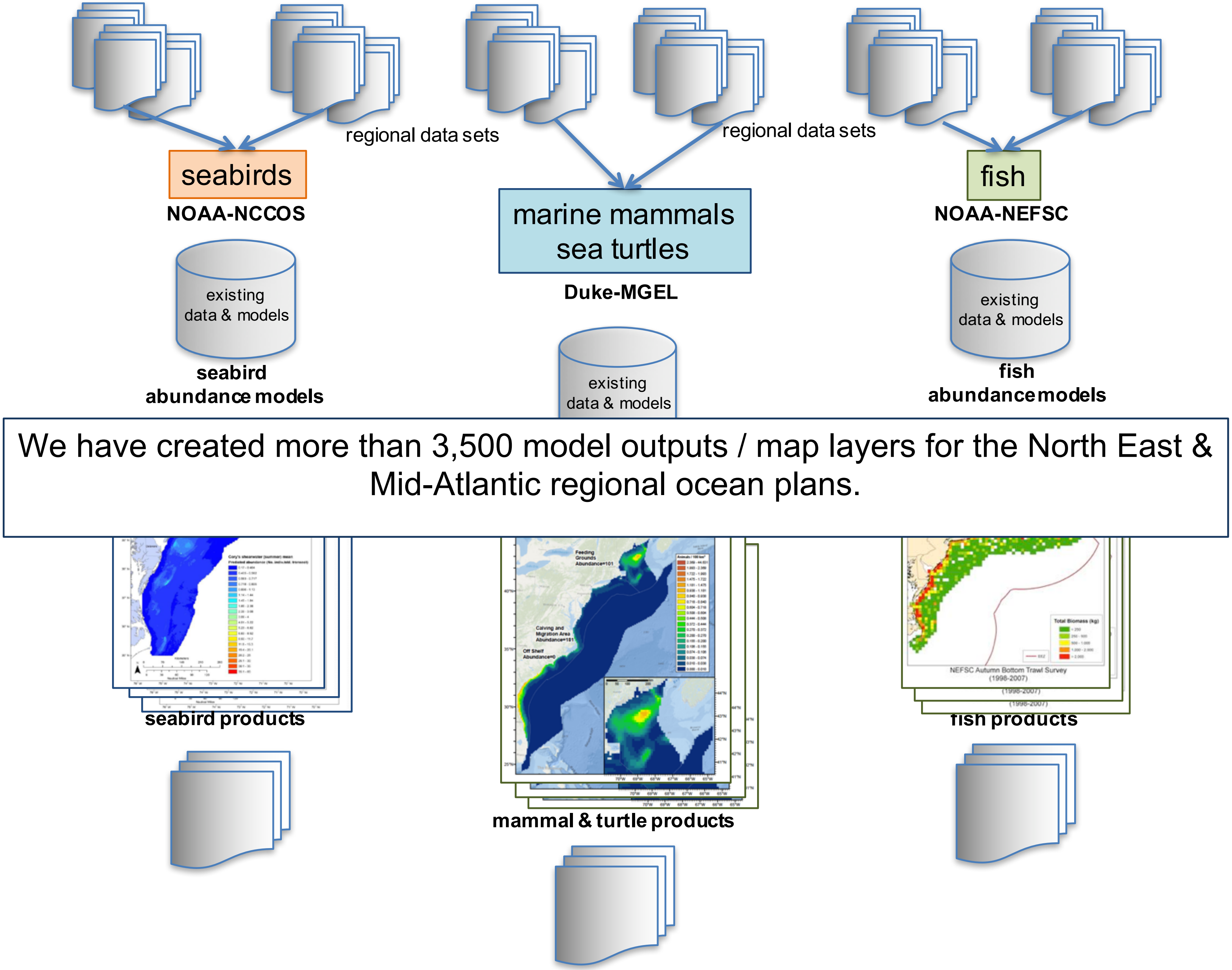
Marinelife **D**ata & **A**nalysis **T**eam

Marine Geospatial Ecology Lab
Duke University

NCCOS

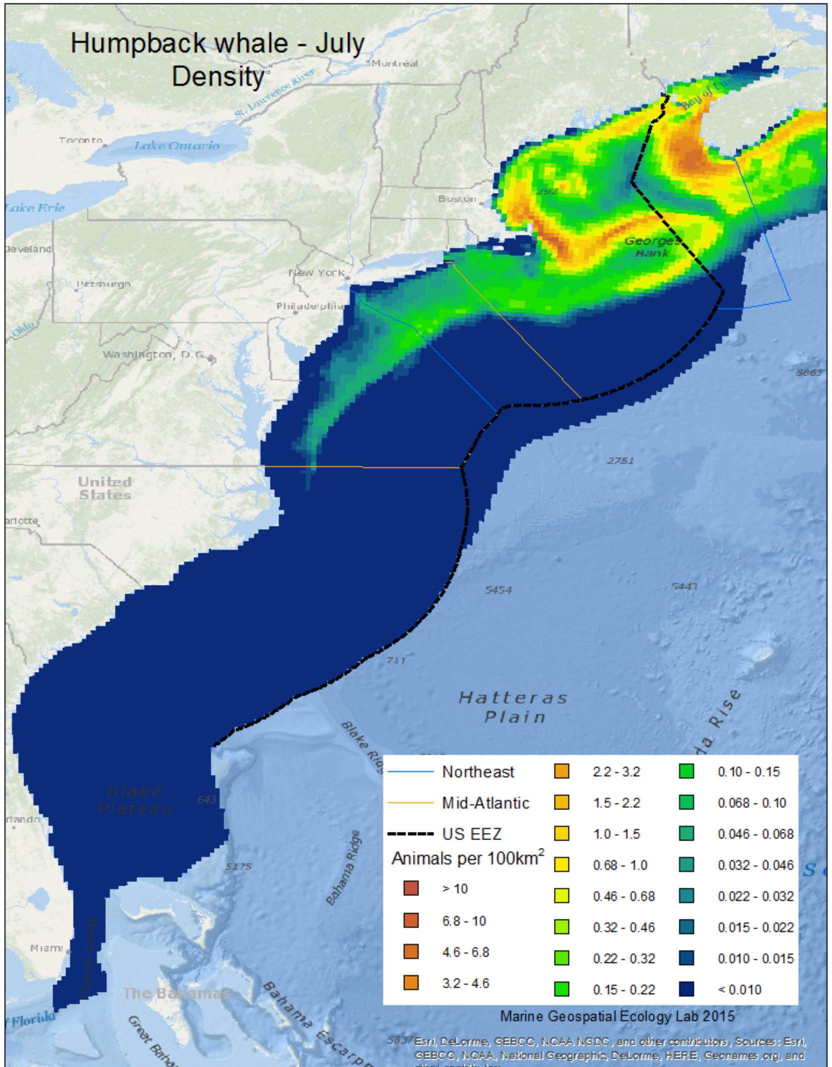
NOAA
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

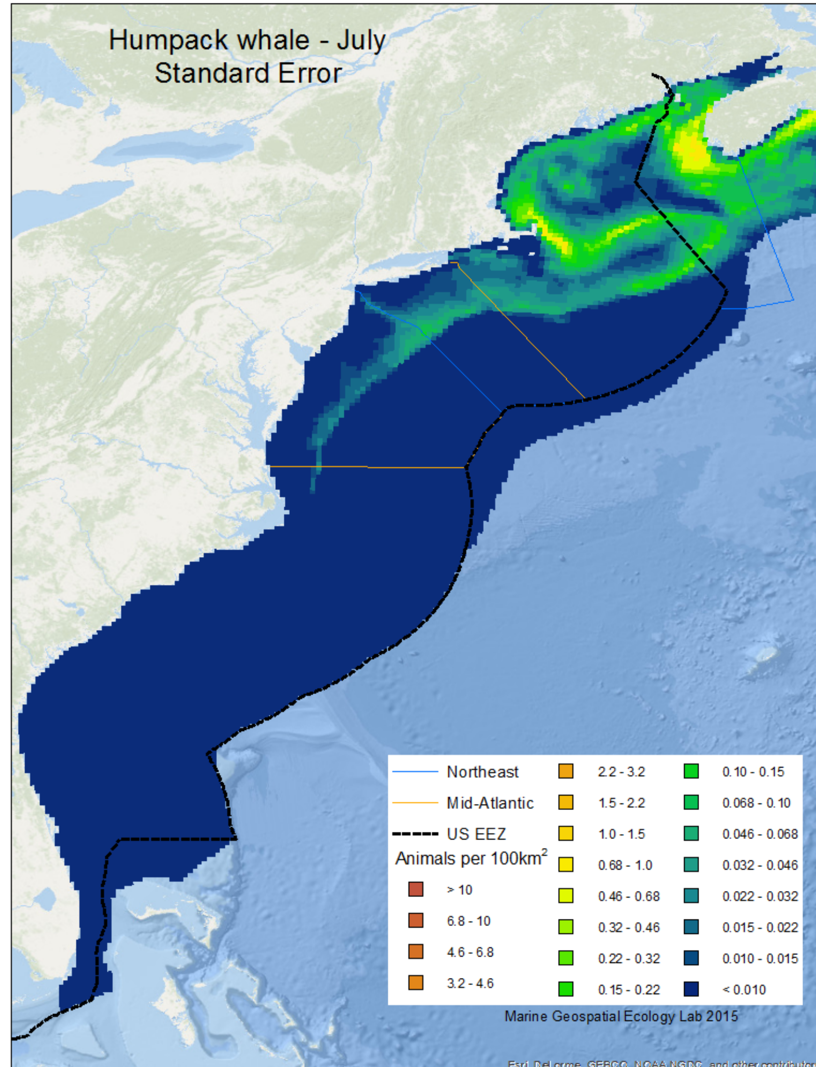
We are working on preparing data for the region but there is no official ***RPB*** planning process underway.



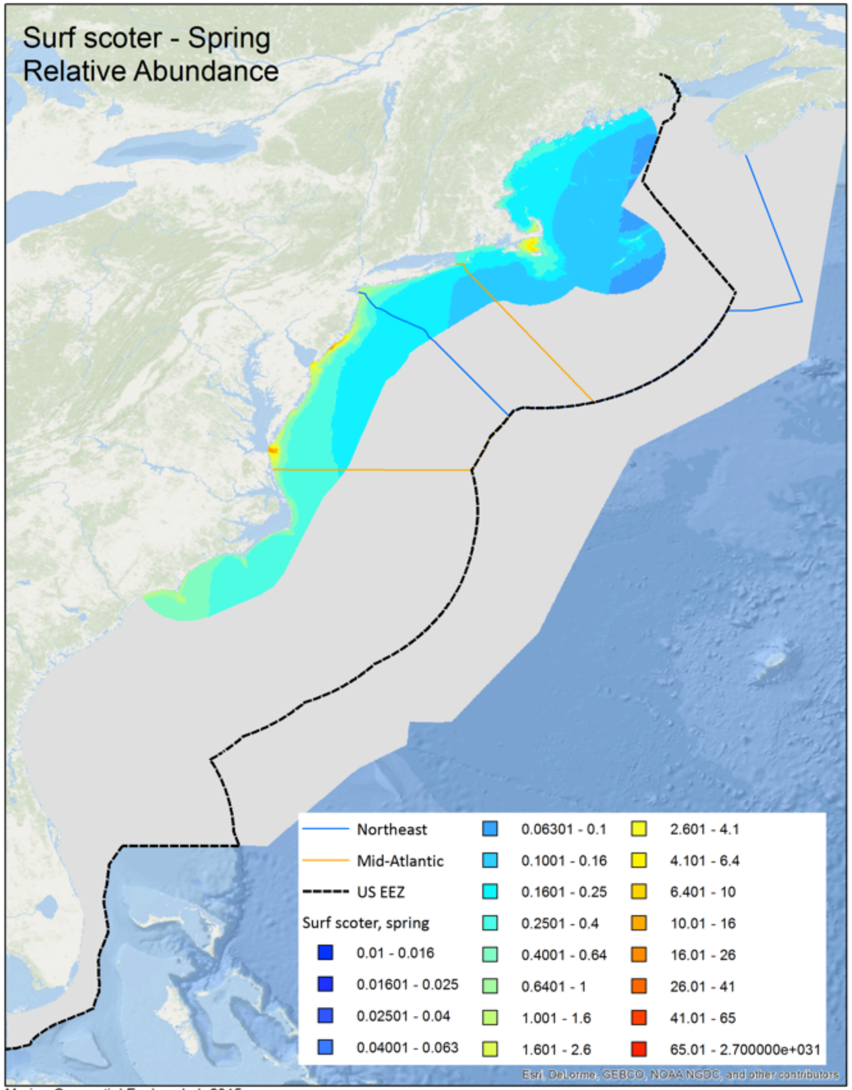
regional data sets
regional data sets
seabirds
NOAA-NCCOS
marine mammals
sea turtles
Duke-MGEL
fish
NOAA-NEFSC
existing
data & models
seabird
abundance models
existing
data & models
existing
data & models
fish
abundance models
We have created more than 3,500 model outputs / map layers for the North East & Mid-Atlantic regional ocean plans.
Feeding Grounds Abundance=101
Calving and Migration Area Abundance=181
Off Shelf Abundance=0
Total Biomass (kg)
NEFSC Autumn Bottom Trawl Survey (1998-2007)
seabird products
mammal & turtle products
fish products

Mammal base product – Humpback whale *(Megaptera novaeanglia)* density & uncertainty

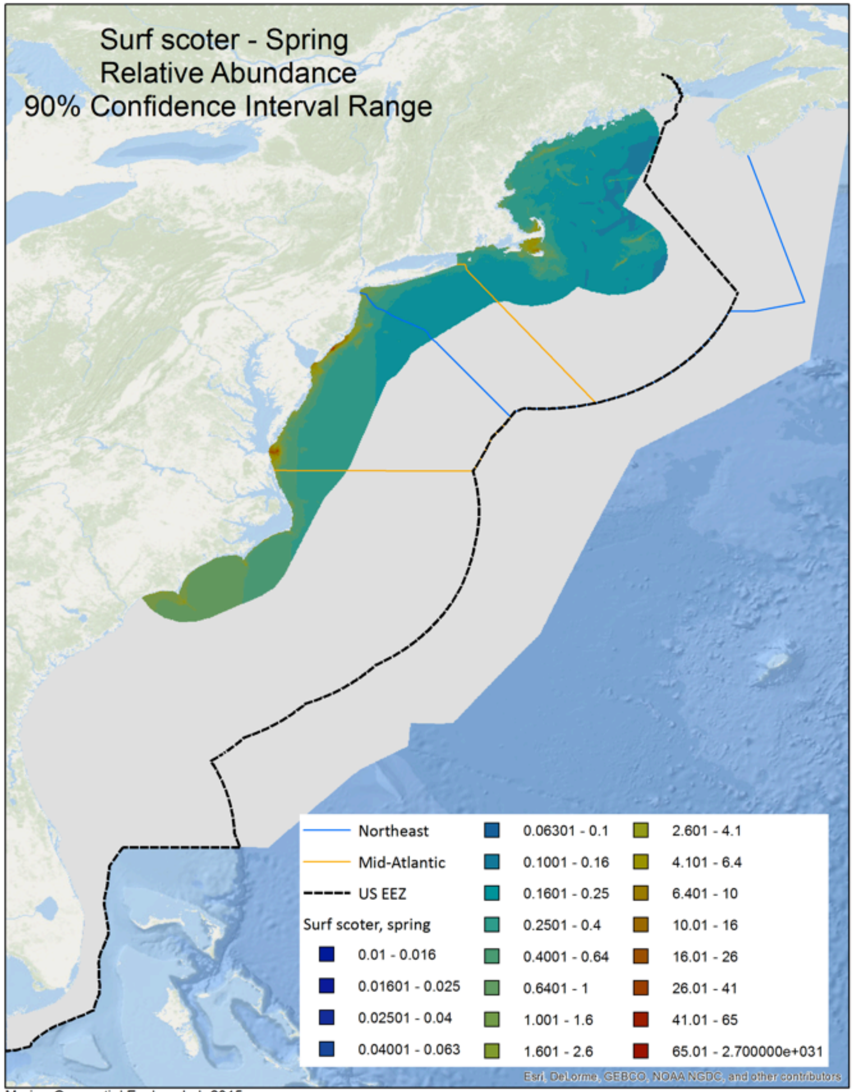




Avian base product – Surf Scoter *(Melanitta perspicillata)*
Abundance & Uncertainty

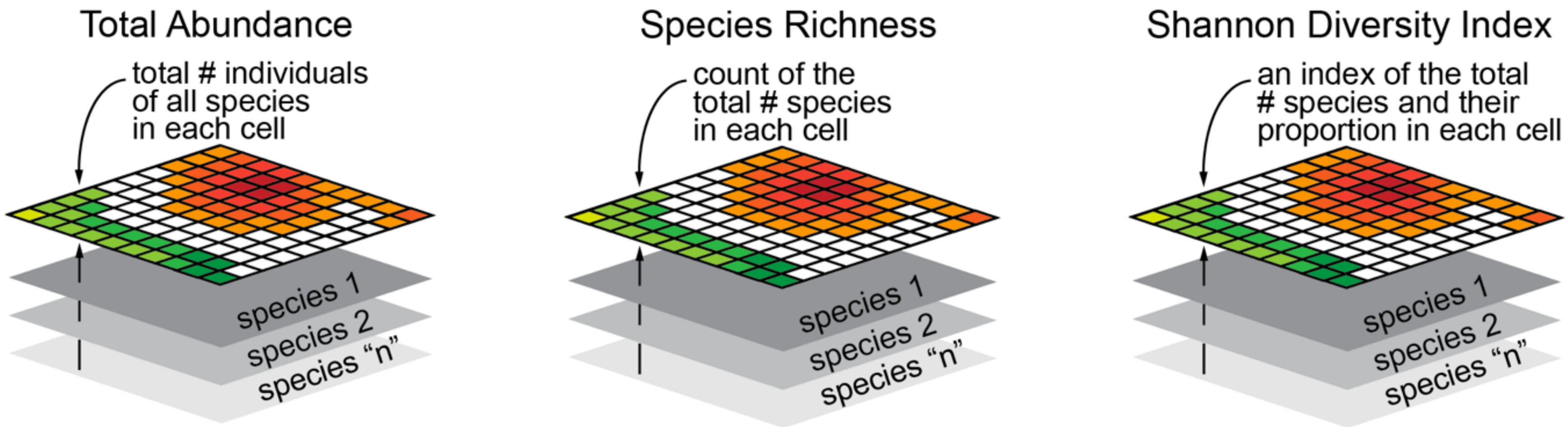


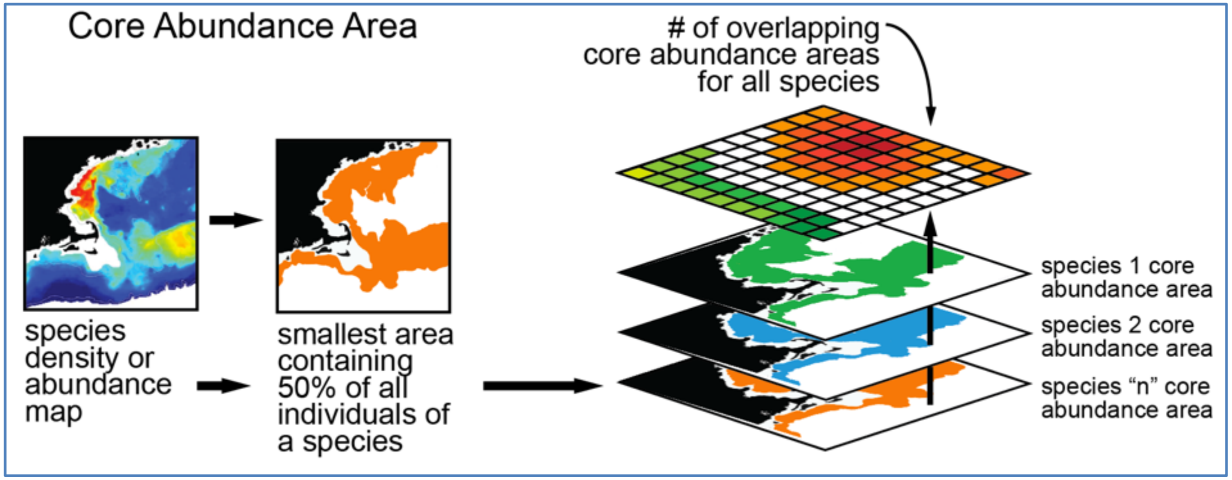
Marine Geospatial Ecology Lab 2015



Marine Geospatial Ecology Lab 2015

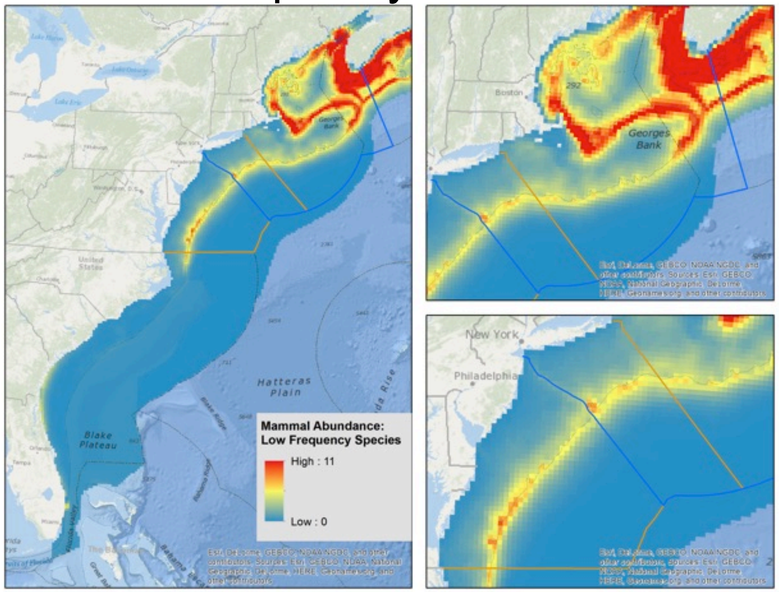
Species Groups: Ecological, Biological, Management-relevant



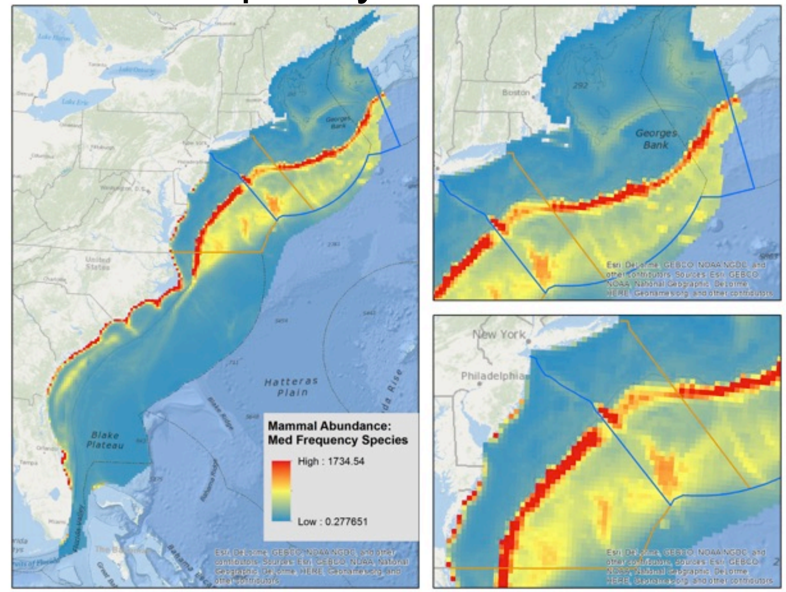


Groups: Cetacean sound use & potential sensitivity to masking

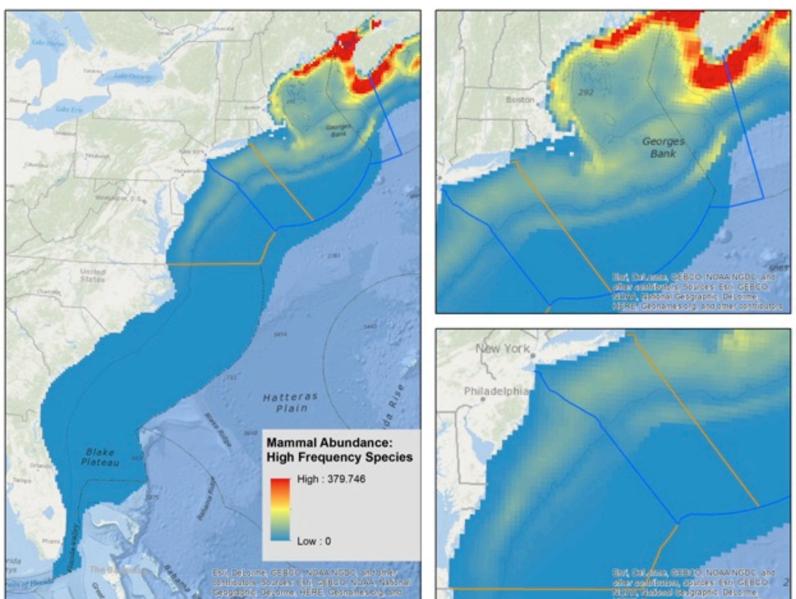
Low-frequency cetaceans



Mid-frequency cetaceans



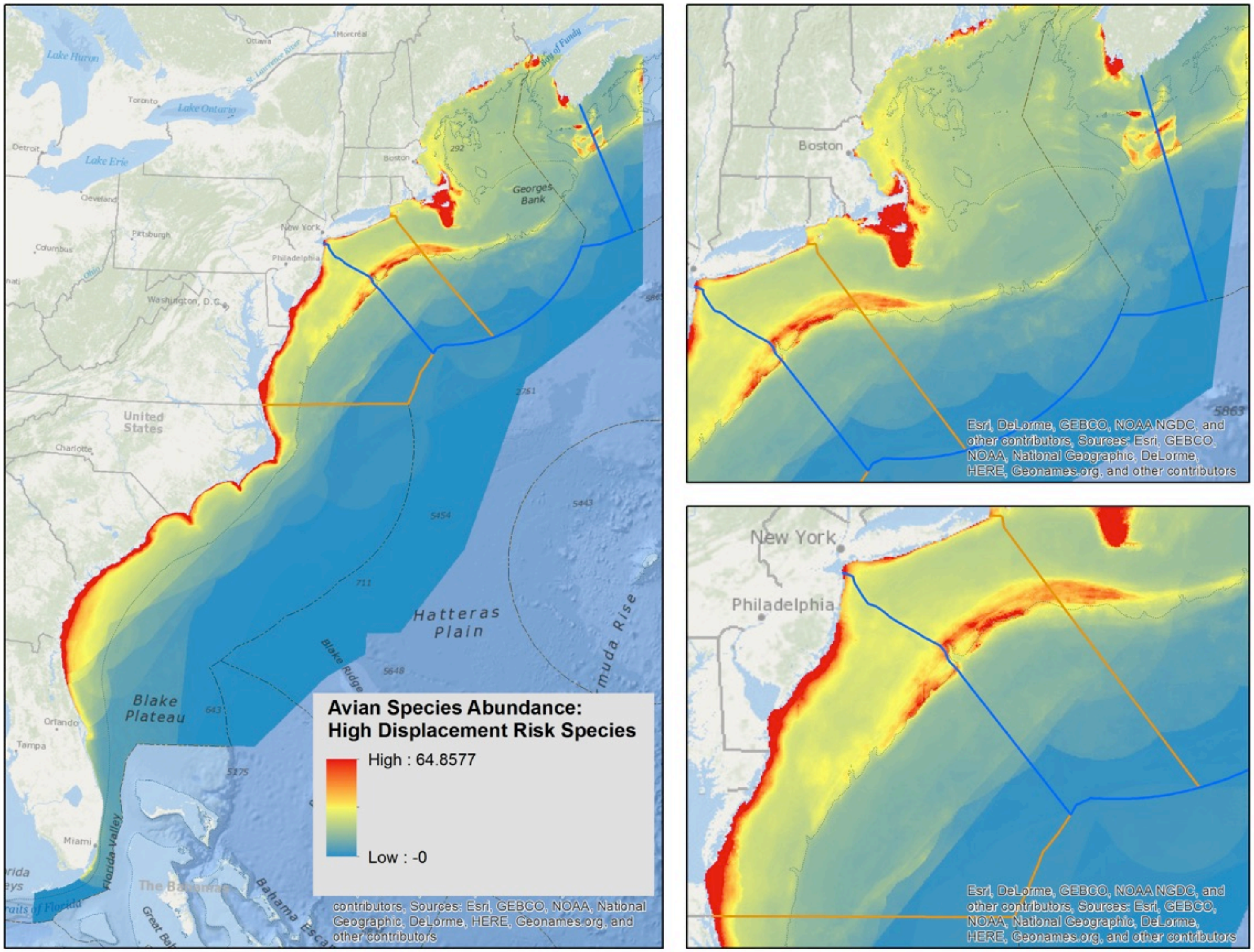
High frequency cetaceans



Functional hearing group	Estimated auditory bandwidth	Genera represented (Number species/subspecies)	Frequency-weighting network
Low-frequency cetaceans	7 Hz to 22 kHz	*Balaena, Caperea, Eschrichtius, Megaptera, Balaenoptera* (13 species/subspecies)	M_{lf} (lf: low-frequency cetacean)
Mid-frequency cetaceans	150 Hz to 160 kHz	*Steno, Sousa, Sotalia, Tursiops, Stenella, Delphinus, Lagenodelphis, Lagenorhynchus, Lissodelphis, Grampus, Peponocephala, Feresa, Pseudorca, Orcinus, Globicephala, Orcaella, Physeter, Delphinapterus, Monodon, Ziphius, Berardius, Tasmacetus, Hyperoodon, Mesoplodon* (57 species/subspecies)	M_{mf} (mf: mid-frequency cetaceans)
High-frequency cetaceans	200 Hz to 180 kHz	*Phocoena, Neophocaena, Phocoenoides, Platanista, Inia, Kogia, Lipotes, Pontoporia, Cephalorhynchus* (20 species/subspecies)	M_{hf} (hf: high-frequency cetaceans)

Southhall, B. *et al.* 2007. Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. Aquatic Mammals.

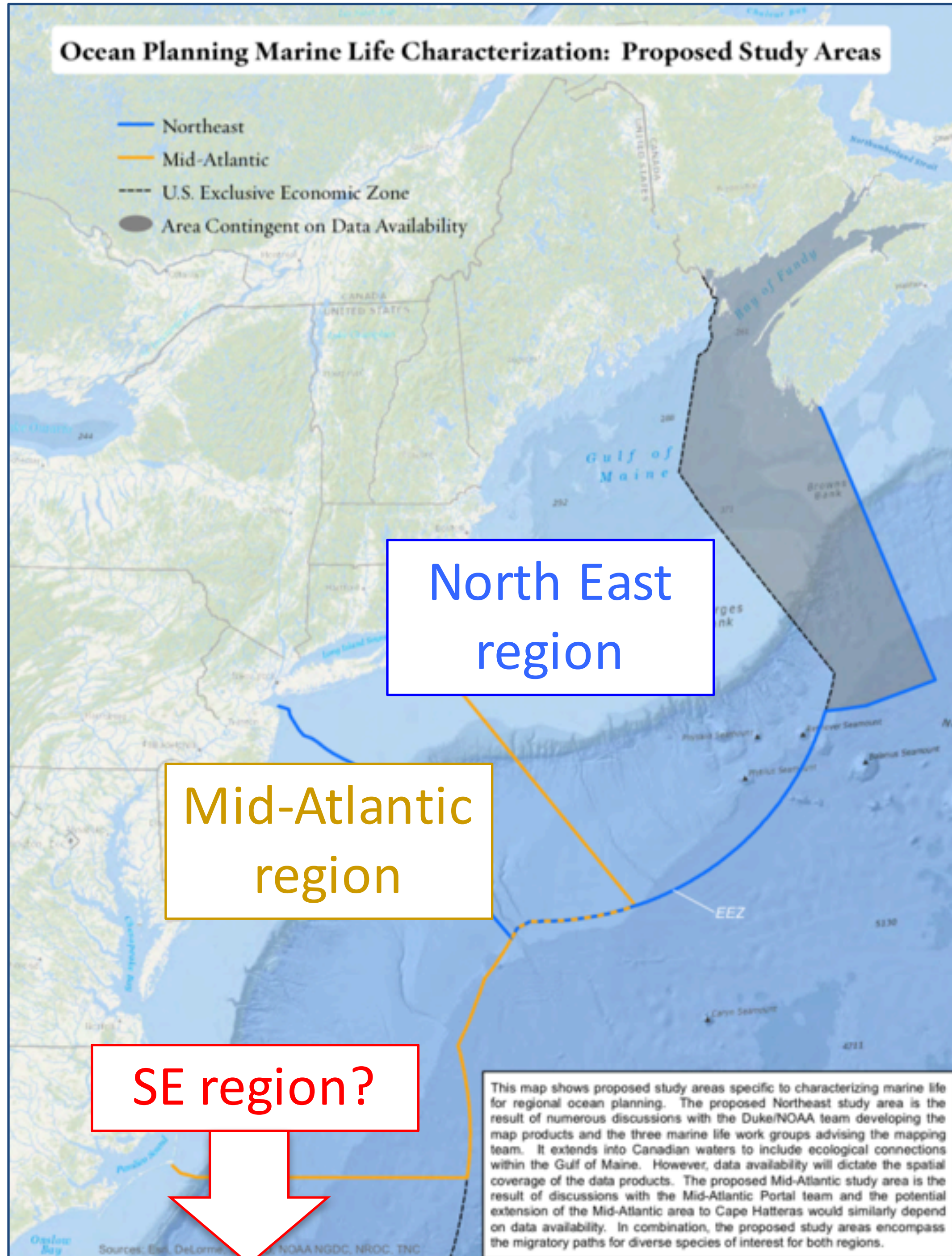
Avian Abundance
High Displacement Risk Species

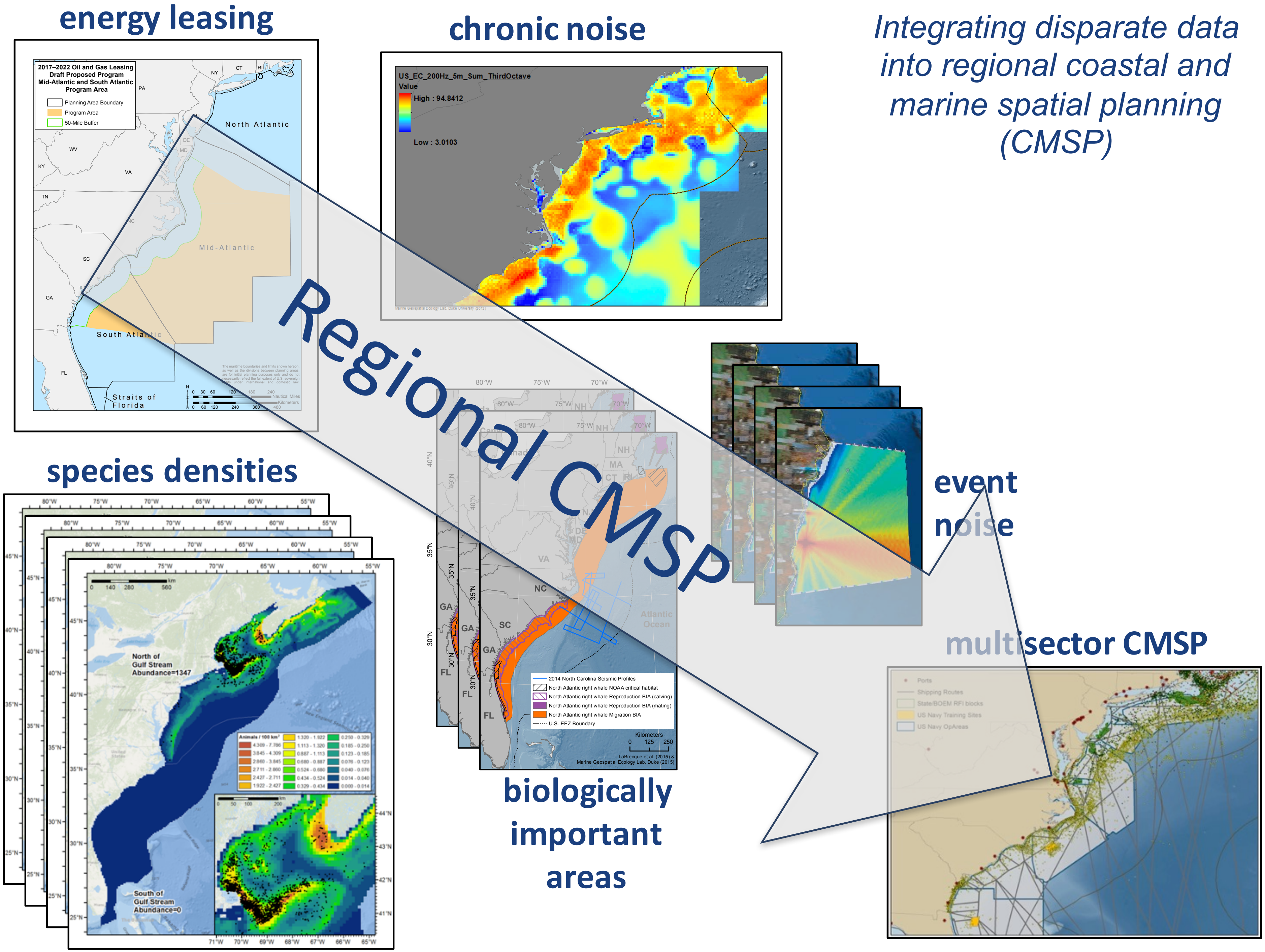


MDAT: Distribution and abundance of marine mammals, turtles, birds and fish

Broad, regional approach

- Consistent
- Seamless
- Multi-scale





Integrating disparate data into regional coastal and marine spatial planning (CMSP)
energy leasing
2017–2022 Oil and Gas Leasing Draft Proposed Program Mid-Atlantic and South Atlantic Program Area
Planning Area Boundary
Program Area
50-Mile Buffer
North Atlantic
Mid-Atlantic
South Atlantic
Straits of Florida
chronic noise
US_EC_200Hz_5m_Sum_ThirdOctave
Value
High : 94.8412
Low : 3.0103
Regional CMSP
event noise
species densities
North of Gulf Stream Abundance=1347
South of Gulf Stream Abundance=0
Animals / 100 km²
biologically important areas
2014 North Carolina Seismic Profiles
North Atlantic right whale NOAA critical habitat
North Atlantic right whale Reproduction BIA (calving)
North Atlantic right whale Reproduction BIA (mating)
North Atlantic right whale Migration BIA
U.S. EEZ Boundary
Atlantic Ocean
LaBrecque et al. (2015) & Marine Geospatial Ecology Lab, Duke (2015)
multisector CMSP
Ports
Shipping Routes
State/BOEM RFI blocks
US Navy Training Sites
US Navy OpAreas



Data Needs and Collaborative Opportunities

- Regional biological data synthesis
  - Extend MDAT work to the Southeast
  - IOOS BDP
  - SALCC Conservation Blueprint

- Marine spatial planning suporting management needs
  - Wind energy planning, Seismic survey permitting

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